# FRED Reports

GULKANA RIVER SOCKEYE
ENHANCEMENT
July 1, 1980 - June 30, 1981
BY
Kenneth Roberson
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Number 30

**Alaska Department of Fish & Game**
Division of Fisheries Rehabilitation,
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ABSTRACT

This report describes the Gulkana sockeye salmon (Oncorhynchus nerka) enhancement work conducted in interior Alaska during FY 81. The primary objective of the project was to continue the evaluation of streamside incubation units as a means of enhancing indigenous sockeye salmon stocks. Ten new incubator units were installed in August and early September, increasing the total number of units to 20. During September and early October, 17 units were loaded with an estimated 6.2 million sockeye salmon eggs. Malachite green was administered monthly to retard fungus growth. Dissolved oxygen and pH were monitored until fry emerged in April.

An estimated 5.2 million fry emerged from April to August, 1981, for a survival of 84 %. During May and June, 1.8 million fry were transplanted to Gunn Creek, a Summit Lake feeder stream. The Gulkana incubation contribution to the adult return was estimated to be approximately 7200 fish from fry released in 1976 and 1977.

A smolt coded wire tagging program was initiated at the outlet of Summit Lake in June of 1981. Two thousand three hundred and sixty smolts were captured and 1442 were coded wire tagged. Pre-fertilization limnological research began in August of 1980 to assess the feasibility of enhancement expansion.

KEY WORDS: coded wire tagging, enhancement, incubation units, Oncorhynchus nerka, sockeye salmon

# INTRODUCTION

The sockeye salmon (Oncorhynchus nerka) of the Copper River are subjected annually to intense commercial, recreational, and subsistence use. While most use occurs in the lower portions of the river, most production is from the many lake systems within the Copper River Basin. Several areas contribute significantly to total production. One in particular is that section of the upper east fork of the Gulkana River between Paxson and Summit Lakes (Figures 1, 2 and 3). It is the subject of much of this paper.

Because of increasing use by all groups and an apparent natural decline beginning in 1964, the Copper River sockeye salmon stocks have generally decreased in abundance in recent years. This decrease has required restrictions on all user groups. In 1979 low escapements resulted in fishery closures for all sockeye stocks in the Copper River. In 1980 limited catches were allowed by all but commercial user segments, which were shut down completely.

As part of an experiment aimed at enhancing depressed Copper River sockeye stocks (especially upper east fork Gulkana stocks), unmanned streamside incubator boxes were installed and have been in operation on the Gulkana River since 1973. During the period 1973 through 1978, effectiveness of the boxes as an enhancement tool was demonstrated (Roberson et al. 1978a, 1978b). In 1979, the facility began an expansion program designed to make the transition from an experimental pilot project to a 20-million egg production facility. Present capacity of the facility is 10 million eggs with expansion slated for the near future.

## Project Background

The project initially was designed to enhance upper east fork Gulkana River sockeye stocks, which had been undergoing severe depletion from the combined effects of harvesting and by the erosion of spawning habitat. From 1964 to the present, the spawning population in the affected area declined from about 60,000 to 25,000 (Roberson et al. 1981). Habitat erosion probably caused most of the decline. In 1964 severe flooding occurred in prime spawning areas within the main Gulkana River between Summit Lake and Paxson. During this flood, severe scouring of the stream bed eliminated spawning gravel. Most stream meanders, important in reducing velocity, were also eliminated. The adjacent Richardson Highway was also destroyed. In reconstruction of the highway, the roadbed was widened into parts of the river and built up, thus, further reducing spawning habitat and altering the ability of the stream to restore itself to former configurations. This condition persists, with most spawning in this area occurring in several warm water springs adjacent to the impacted segment. These springs are the site of the Gulkana incubation facility (Figures 2 and 3).

After determining the need for enhancement, budget constraints dictated that a low cost, relatively maintenance-free system would be desirable.

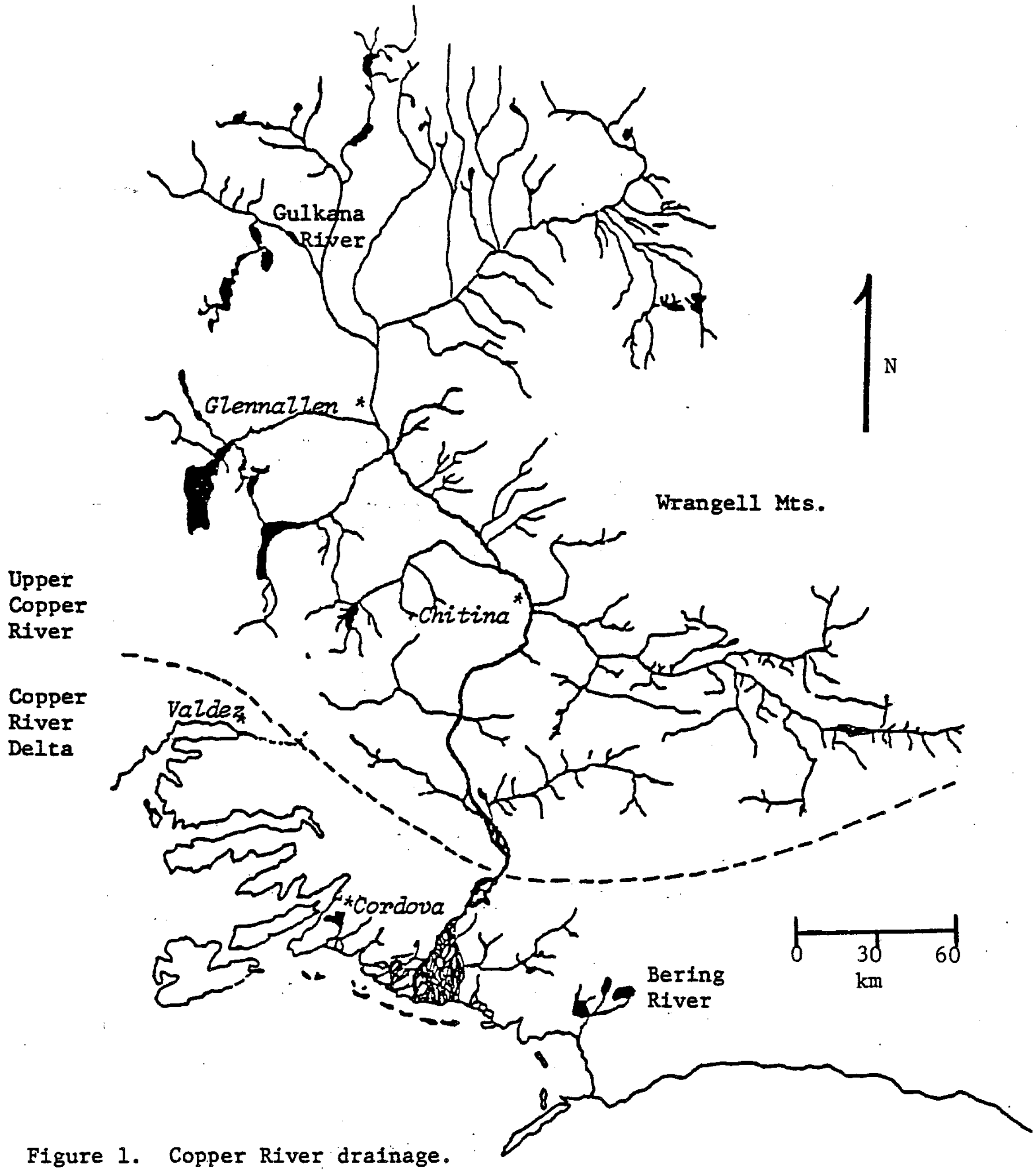



Figure 1. Copper River drainage.

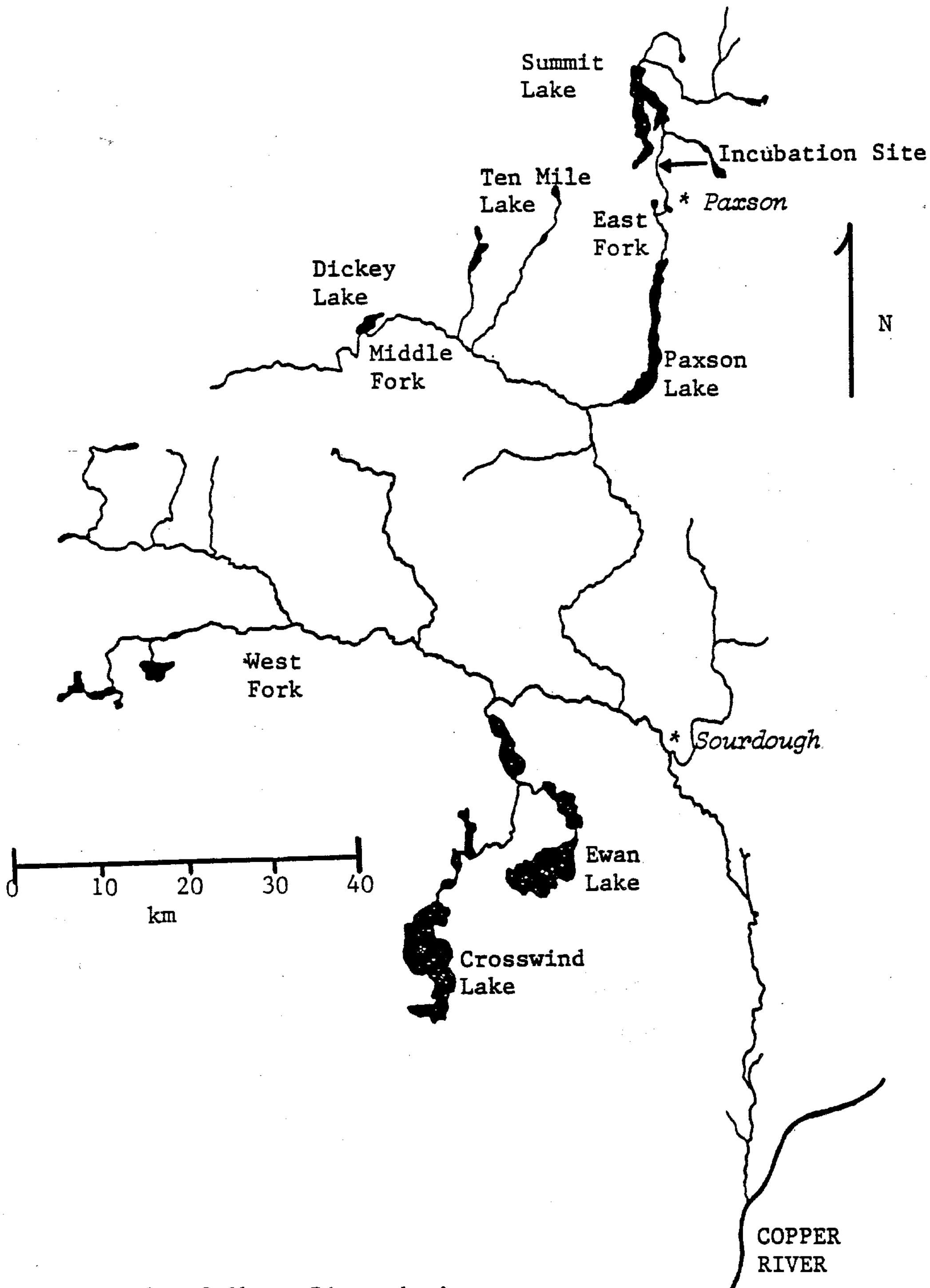



Figure 2. Gulkana River drainage.

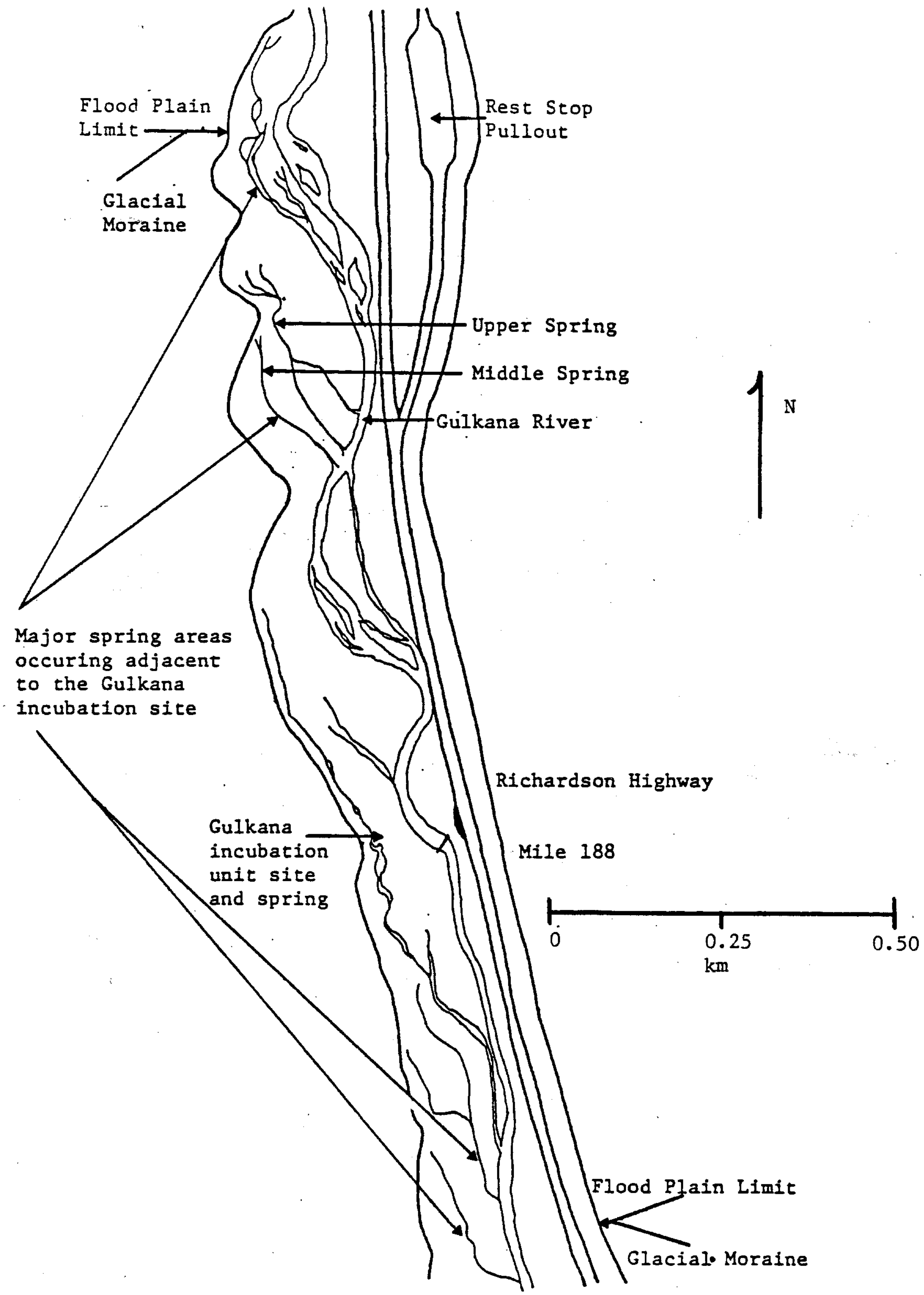



Figure 3. Gulkana River and incubation spring location.

After examining some of the more traditional techniques, the staff developed the then fairly unique concept of streamside incubation boxes.

The incubation unit idea was imported to Prince William Sound, Alaska, by Mr. J. David Solf, Commercial Fishery Biologist for ADF&G, after visiting a Canadian incubation facility on the Fraser River, which utilized incubation boxes constructed by Mr. George Wilson, an International North Pacific Fisheries Commission (INPFC) Biologist. After observing the success of the Wilson type box, Mr. Solf built and installed several similar incubation units near Cordova and successfully incubated pink salmon eggs to fry with excellent survival rates. After communication with Dr. Bill McNeil and Mr. Jack Bailey at the Auke Bay National Marine Fisheries Service (NMFS) Laboratory and Mr. Robert S. Roys, Director, FRED Division, ADF&G, it was agreed that the upper Gulkana River spring area was a candidate for an enhancement project using incubation boxes. After a year of baseline water temperature and water chemistry monitoring, a spring area was chosen for the pilot incubation unit.

Initial goals of the project were:

(1) Enhance present sockeye salmon stocks in the Copper River, with particular emphasis placed on upper east fork Gulkana River stocks.

(2) Evaluate incubation boxes as an enhancement technique using upper east fork Gulkana River spring water (Gulkana Springs) and stocks indigenous to the springs.

(3) Establish sockeye salmon brood stock at the Gulkana Springs for eventual use in a production hatchery facility.

Although preliminary evaluation indicated success of the technique and the production phase has begun, these goals still apply.

The first experimental incubation box was constructed after consulting ADF&G staff engineers, Mr. Gil Ziemer and Mr. George Cunningham. This pilot unit was installed in the fall of 1973 and loaded with approximately 225,000 green eggs obtained from spawning salmon in adjacent spring areas. The first year's estimated green egg to fry survival of 79% demonstrated the efficacy of the technique. In 1974 an additional four units of identical design were installed in a nearby spring spawning area. In 1975, because of poor water flows, the original unit was moved to the site of the newer units. Water flows at the new site were not a limiting factor, as there is a stable flow of adequate volume year-round. In addition to the 5 units used in previous years, 5 more were added in 1979, and 10 more in 1980, providing 20, linearly-arranged incubator units. With the exception of the three units in 1980, all units were loaded with green eggs each year (Table 1).

Table 1. Historical summary of estimated sockeye salmon production from the Gulkana incubation system, 1973 to 1981.

| Year | Number of Incubation Boxes (Substrate) | Total Green Eggs Seeded (Thousands) | Total Resultant Fry Outmigrants (Thousands) | Estimated Percent Survival |
|---|---|---|---|---|
| 1973-74 | 1 (Gravel) | 226 | 179 | 79.4 |
| 1974-75 | 5 (Gravel) | 1,270 | 887 | 70.0 |
| 1975-76 | 5 (Gravel) | 1,280 | 728 | 57.0 |
| 1976-77 | 5 (Gravel) | 1,290 | 629 | 48.8 |
| 1977-78 | 5 (Gravel) | 1,360 | 584 | 42.9 |
| 1978-79 | 5 (Gravel) | 1,320 | 1,040 | 78.8 |
| 1979-80 | 6 (Gravel) | 2,040 | 1,630 | 79.9 |
| | 4 (Intalox) | 1,530 | 817[a/] | 53.6 |
| 1980-81 | 18 (Gravel) | 5,520 | 4,650 | 83.7 |
| | 2 (Intalox) | 677 | 603 | 89.1 |

a/ Bear climbed in one box severely disturbing eggs.

## Study Area, Water Source and Quality

The incubation facility is located in north-central Copper River Basin, approximately 416 km upriver from the Copper River flats and 3 km downstream from Summit Lake. The site lies inside the following coordinates: $63^{o}$ 4' - $63^{o}$ 05' north latitude and $145^{o}$ 30' - $145^{o}$ 31 west longitude. Elevation of the site is about 921 m. The facility is located across the Gulkana River opposite Milepost 188 of the Richardson Highway (Figures 1, 2 and 3).

This site was chosen for the initial incubation feasibility study because of naturally occurring springs of exceptional water quality. The springs are natural aquifers, which probably originate from Summit Lake. The water is filtered through several hundred meters of glacial moraine deposited by the Gulkana Glacier during its recession. Beginning in the fall of 1971, these spring areas were monitored for water temperature, clarity, and flow and were observed to be open and flowing even at minus 51 C. Water temperature and flow measurements recorded during the 1972-73 winter confirmed the suitability of the springs as a water source for salmonid egg incubation. Later measurements of other spring water quality parameters compared well to pre-project water quality (Table 2).

# MATERIALS AND METHODS

## Incubation Box Theory, Construction, Installation and Maintenance

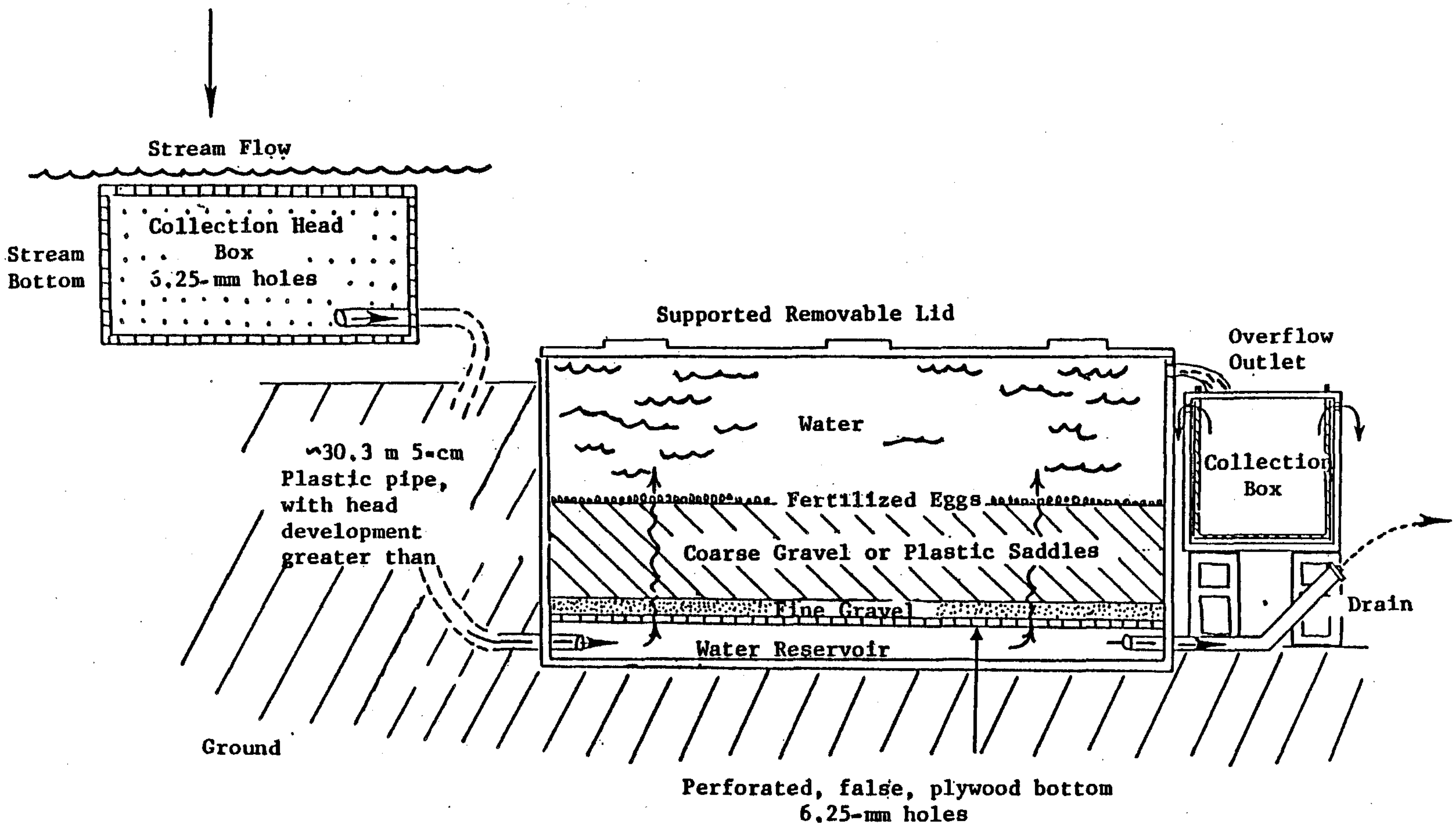
The Gulkana incubation boxes work on the principle of upwelling water passing through incubating eggs. This provides oxygen and at, the same time, removes waste products (Figure 4). The box serves as a container for the water, substrate, and eggs; it excludes light and protects eggs and alevins. Within the incubators, fertilized eggs rest upon a substrate (a facsimile of the natural habitat for the alevins), which provides a medium for incubating eggs. At swim-up, the fish leave the incubation unit for the instream phase of their life cycle.

Each incubator measures 2.44 m x 1.22 m x 1.22 m and is constructed of 1.9-cm (3/4 in) AC plywood. Each has a perforated (6.4-mm holes on 31.8-mm centers), 1.9-cm (3/4-in) plywood false plate located 12 cm above the incubator bottom. Water intake and outflow is accomplished through 5.1-cm inside diameter (I.D.) polyethylene pipe, with each incubator fitted with an easily accessible drain pipe. For protection and insulation purposes, each incubator is buried with the top flush with the ground surface. A lid of 1.9-cm (3/4-in) AC plywood reinforced with 5 x 15-cm (2-in x 6-in) planks covers the box by fitting snugly within the inside top, resting easily on 5 x 15 cm (2 in x 6 in) incubator corner and wall supports.

Water for each incubator is supplied from head-boxes buried in spring gravel upstream from the respective incubators. At least 1.22 m of true head is provided. The head-boxes are 1.22-m x 1.22-m x 0.61-m x 1.9-cm (3/4-in) AC plywood with 6.25-mm diameter perforations on all faces. A

Table 2. Gulkana incubation spring water quality data.

| Water Quality Variable | Average Values |
|---|---|
| Temperature | 2.2 - 5.5 C |
| Carbon Dioxide ($CO_2$) | 5 mg/liter |
| Alkalinity | 86 ppm |
| pH | 8.5 |
| Dissolved Oxygen (DO) | 8 - 12 ppm |
| Total Hardness | 68 ppm |
| Conductivity | 112 micro ohms/cm |
| Ammonia ($NH_4$) | 0.0 - 0.2 mg/liter |
| Flow | 0.34 $m^3$/sec |




Scale: 25 mm = 60 cm

Figure 4. Plywood reinforced upwelling incubation unit currently in use at the Gulkana incubation site.

30-m length of buried polyethylene pipe (5.1 cm, I.D.) connects each head-box to an incubator and provides an upwelling water flow of 95 liters/min/unit.

Each incubator has a 7.6-cm layer of 1.27-cm minus pea gravel over the false plate. This prevents downward migration of alevins through the plate and also serves to filter larger debris from upwelling water. On top of the pea gravel, and serving as the egg substrate, is either 30.5 cm of 1.9 to 3.8-cm graded, rounded, river run gravel, or 30.5 cm of Intalox plastic saddles (Figure 5).

After loading the incubators with substrate, they are filled and flushed several times. As a last step prior to loading green eggs, each incubator and its contents are treated with 3.1 ppm malachite green.

During late August and September of 1980, 10 new incubators were transported to the site and fitted with intakes, drains, and water lines. They were positioned in the same linear alignment as the older units, bringing the total number of available incubators to 20 and the incubation capacity to an estimated 10 million eggs.

The installation and preparation of 10 new units during August, when normally the older units would be in the process of being cleaned, caused the egg take crew to be split up during the first part of the egg take. Two persons were assigned to finish the cleaning of the units, while the rest of the crew participated in the egg take. All of the units were cleaned and ready for eggs by the end of September.

Prior to loading green eggs each fall, the incubators were cleaned of the dead eggs, fungus, and detritus from the previous year's batch of eggs. To prevent the release of any harmful organisms into the springs, each unit was disinfected by treating with 1550 ppm of Chlorox for 24 hours, after which the lid was removed to allow the sun to neutralize the Chlorox. After a 48 hour neutralizing period, the unit was flushed with spring water. This process was repeated once, after which the units were ready for cleaning.

Cleaning of each unit involved processing all substrate material through a cement mixer and water flush. After cleaning, the substrate was either put onto a tarp for later loading or was reloaded immediately into a prepared incubator. After the units were empty of substrate, they were scrubbed down and any needed repairs were done. After this was accomplished, all incubators were loaded with respective substrate material, thus completing the preparation tasks prior to receiving green eggs.

Egg Take

The majority of the egg take was conducted about 50 m away from the incubation units, near the incubator pool (Figure 6). This pool is as far upstream of the incubation spring as spawners can proceed; thus, they tend to congregate there. The pool is about 15 m long, 8 m wide,

Polypropylene Intalox Saddles
For Salmon Egg Incubation Substrate

| | |
|---|---|
| Specific Gravity | $1.13 \pm 0.02$ |
| Weight of one Saddle | 2.24 g. |
| Volume of one saddle | 1.98 ml. |
| Void space incubator | $\pm$ 92% |
| Dry weight of 1 $m^3$ of saddles | 91.3 kg |

Actual size top view

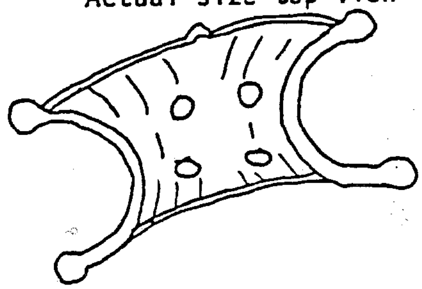


Figure 5. Polypropylene Intalox plastic saddle subtrate specifications and diagram. One cubic meter of saddles delivered by the manufacturer occupies approximately 1.28 $m^3$ of space in the incubator unit.

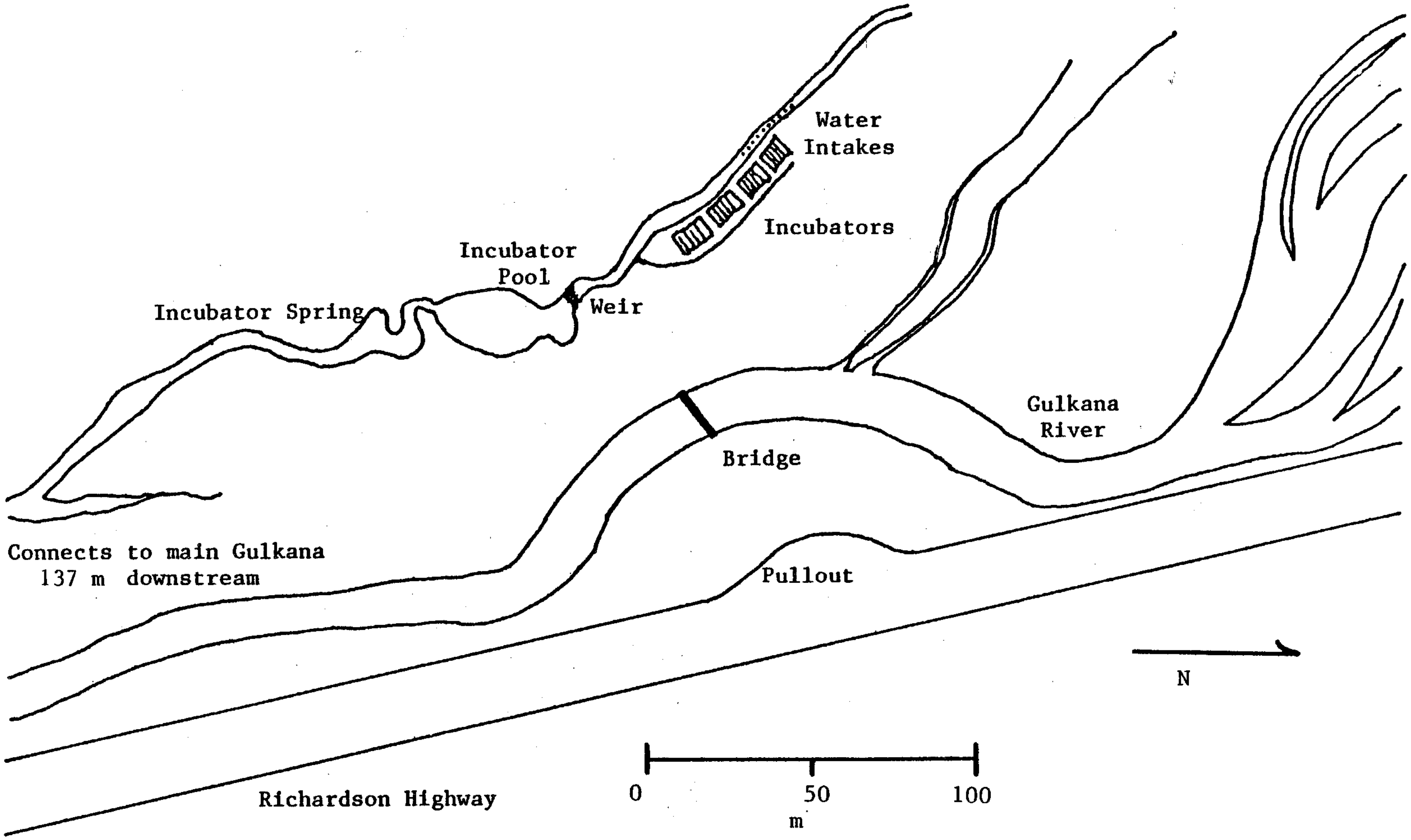



Figure 6. Gulkana River incubation site.

and 0.5 m deep, and is the site of heavy natural spawning. The adult sockeye were dip netted, checked for ripeness, and if useable, were killed with a blow to the head. The basic egg-take procedure was set forth by McNeil and Bailey (1975). Each fish was wiped with a paper towel prior to spawning to make sure no blood, slime, or dirt contaminated the egg-take basin. Spawning utensils, gloves, and equipment were disinfected using a 200 ppm iodophore solution.

For spawn taking, eggs from two females, followed by milt from two males, were placed in an enameled metal basin. Next, sufficient water was added so the eggs could move freely. The eggs were then stirred with a feather to ensure adequate mixing of eggs, milt, and water. After 30 seconds, the fertilized eggs were rinsed in noncontaminated (not exposed to adult salmon) spring water and then poured into 22-liter buckets to water harden. After water hardening for at least 1 hour, the eggs were transported to the incubation unit for processing and loading. The eggs were measured volumetrically from the buckets in 1-liter lots, using a plastic dipper and a 1000-ml graduated cylinder. After at least 4 liters of eggs were removed from each bucket, a 1-liter sample of eggs was counted from each bucket, and this number was multiplied by the total liters of eggs/bucket to estimate the number of eggs per bucket. By knowing the number of females/bucket, the approximate number of eggs/female follows, as do the number of eggs/incubator and number of eggs/day. After measuring and counting, in 1-liter lots, the eggs were poured directly into the incubator, taking care to pour with the cylinder mouth under water.

The upstream incubator of each group of five was loaded first, with subsequent loadings occurring in a downstream direction. This avoided disturbing previously seeded eggs. After each unit was loaded, the lid was put on and three large rocks placed on top to indicate a loaded unit. All units were monitored monthly until fry emergence in the spring. Monthly monitoring included checking the outflows for proper flow, flushing the units of detritus, measuring dissolved oxygen and pH with a Hach kit, flushing each unit with a 3.1-ppm malachite green treatment, and cleaning the head boxes of algae and accumulated gas bubbles. Ryan thermograph units, which have been recording spring water temperatures since September 1973, were maintained on a monthly basis. Temperature units (1 T.U. = 1 degree C above zero for 24 hours) were calculated from the thermograph charts and provided the cumulative number of temperature units for incubation.

### Fry Emergence

For evaluation of the incubation units, the egg take, and the effects of different variables, the emerging fry were captured and held in collection boxes until they could be counted and samples collected. At emergence, the fry swim to the surface of the incubator and are carried to the respective collection box by the outflowing water. The collection boxes were made of 1.6-mm aluminum sheeting, perforated with 1.6-mm holes on 5.6-mm centers. They measure 50.8 cm x 50.8 cm x 83.8 mm. The boxes were assembled with aluminum 90° angle pieces and rivets.

All interior edges and corners of the boxes were covered with silicone caulking to protect the fry.

Fry enumeration involved three separate methods, depending upon the numbers of fry to be counted. When 500 or less fry were involved, individual fish were counted, using a hand tally whacker and small hand net. When numbers of fry in the collection box ranged from 500 to 12,000, the number of fry which produced a displacement of 60 ml of water in a 100-ml graduate cylinder was used as an estimator. The total number of fry in a collection box was then estimated by multiplying the number of fry per sample milliliter by the total volume of fry in milliliters. A weight method was used when the number of fry in a single collection box was greater than 12,000. The weight of a specific amount of water in a bowl was determined by an Ohaus triple-beam balance scale. Emergent fry (with excess water drained off) were added to this water. The number of fry per gram was determined by a subsample count of approximately 100 grams. The total weight of the fry was multiplied by the number of fry per gram in the subsample to obtain an estimate of total fry.

After counting, those fry released on site were placed into a 22-liter bucket filled with water and released into the spring water below unit number one. The distance from the uppermost unit to the release site is about 46 meters.

Fry samples were randomly selected from each collection box at approximately 25%, 50% and 75% of the expected 80% emergence for determining developmental indexes ($k_D$). Wild fry for $k_D$ samples were also collected from One-mile Spring using a small beach seine. Each fry sample was approximately 50 fish and was preserved in a 5% formalin solution for at least 6 weeks prior to processing. These sample fry were not included in either the live or dead cumulative numbers for emergent fry. After the preservation period, individual fry were blotted, weighed (nearest mg), and measured for fork length (nearest 0.5 mm). The degree of ventral slit closure was noted for each fry. The development index was calculated for each fry as follows:

$$k_D = \frac{10\sqrt[3]{\text{weight (mg)}}}{\text{length (mm)}}$$

A mean and standard deviation was calculated for length, weight, and developmental index for each subsample of approximately 50 fry.

This was the second year fry were transported from the incubation site to Gunn Creek, the inlet tributary to Summit Lake. Fry to be transported were carried from the incubation site to the transport tank in 22-liter buckets. The transport tank measures 61 cm x 76 cm x 61 cm, has a volume of 0.28 cubic meters, and was constructed of 1.9-cm (3/4-in) AC plywood surfaced with a fiberglass gelcoat. The tank was set in the bed of the project pickup truck. Prior to loading fry into the tank, water was pumped from the Gulkana River into the tank until it was half full. Pure oxygen was added to the transport tank water through a micropore tube at 10 liters per minute. The tank water temperature was checked against the water in the buckets and equilibrated to within appproximately a 2 C difference before adding fry. The fry were released into Gunn Creek after a 14.3-km trip and after equilibrating the transport tank water to within approximately 2 C of Gunn Creek water. The plug was then pulled on the transport tank and the fry dropped approximately 4.2 m through a flexible hose running from the bottom of the tank to just under the surface of Gunn Creek.

### Smolt Coded Wire Tagging

A temporary building was constructed prior to smolt capture to protect the tagging equipment during its use. The smolt capture net was designed to be a total capture net and was installed on the outlet of Summit Lake. The approximate location and configuration of the capture net is shown in Figure 7. A single fyke-type tunnel net was attached to the two tapered trap wings to make a 93-m smolt capture net.

After the smolts were captured in a live box, they were "dip-netted" and put into a holding pen prior to coded-wire tagging. A borrowed, Northwest Marine Technology, Inc., coded-wire tagger was used during the first year for coded-wire tagging. Smolts were coded-wire tagged, following the Northwest Marine Technology Instruction Manual and the Mark-Tag Manual for Salmon (Moberly et al. 1977).

Smolt age, weight, and length samples were obtained from the mortalities, which occurred during the normal project activities. Condition factor was calculated on each smolt using:

$$K = (W/L^3) \times 10^5.$$

Successfully-tagged smolts were transferred to a second holding pen where they were held approximately 12 hours for observation. Mortalities were counted, then live fish were released 100 m downstream from the capture net. Tag retention was assumed to be 100% in the held and released fish. The tags, which were applied during 1981, were coded - Agency 4, Data 21/5.

### Adult Salmon Investigations

Aerial surveys are flown each fall with local air taxi operators to record the number of adult spawners that were enroute to or already on the spawning grounds. Fish Creek weir was operated from 23 June through 6 August. Ten Mile weir was not operated in 1980 because of the egg take priority and lack of manpower.

### Limnological Evaluations

Limnological investigations of Paxson and Summit Lakes began during the fall of 1980. Three sample stations were established on each lake to

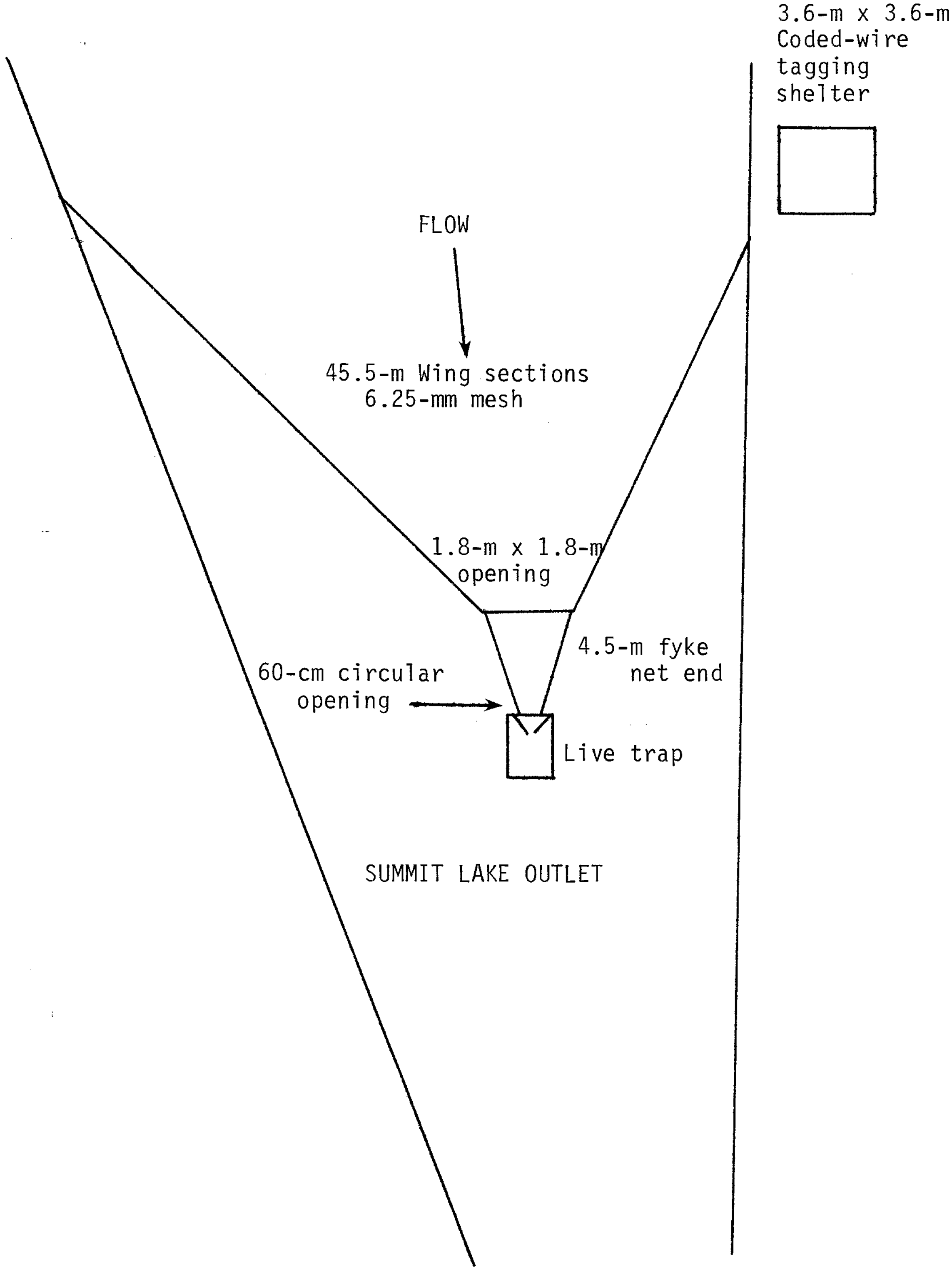



Figure 7. Summit Lake smolt capture and coded-wire tagging site, 1981.

gather baseline data and to examine the feasibility of lake fertilization.

Zooplankton, periphyton, phytoplankton, particulate nutrients, and primary productivity were sampled on a monthly basis throughout the open water period and several times after freeze up. Sampling methods follow the procedures outlined by Koenings et al. (1980).

## RESULTS AND DISCUSSION

### Egg Take

The egg take for the Gulkana incubation units began on 16 September and continued until 13 October. The egg-take numbers ranged from a low of 42,000 eggs, taken on the last egg-take day of 13 October, to a high of 643,000 eggs that were taken on 30 September. The total estimated egg-take for 1980 was 6,290,000 eggs.

The average effective fecundity of the females in 1980 was calculated to be 3,130 eggs per female (Table 3). This is lower than fecundity for Gulkana stocks, which were reported as approximately 3,980. Our calculated average fecundity is based on females used as broodstock. The apparent low fecundity per female in 1980 may be from partially spawned females that were used in egg takes.

Approximately 4,000 adult sockeye salmon were used in the egg-take. The ratio of males to females used was one to one. Except for those carcasses that several dog mushers collected for dog food, all the carcasses were returned to the river after being spawned.

Because of the reduced survival rate which occurred in 1979 in units loaded with plastic saddles (Roberson et al. 1981), only two units contained the plastic saddle substrate in 1980. Plastic saddles were used again in 1980 to either corroborate or refute the previous year's results. Because of broodstock limitations, only 15 gravel substrate units were loaded with green, unpicked eggs, leaving three units empty (Table 4).

For evaluation of optimal egg loading density (eggs/box) of the Gulkana incubators, two units were loaded with greater than 600,000, green, unpicked eggs. The remaining thirteen incubators were loaded with between 42,000 and 483,000, green, unpicked eggs, with an estimated mean of 332,000.

### Fry Emergence

Cumulative temperature units were zero on the day that green eggs were loaded into each incubator. Temperature units within the incubators averaged three per day throughout the incubation period. In the gravel substrate units, a mean of approximately 225 days (723 T.U.'s) transpired until emergence. One thousand fry per day was arbitrarily

Table 3. Gulkana incubation project, estimated sockeye salmon fecundity, 1980.

| Date | Estimated Egg-Take for the Day (thousands) | Number Females Used in the Egg-Take | | Estimated Fecundity |
|---|---|---|---|---|
| 9/16 | 331 | 110 | | 3,010 |
| 9/17 | 347 | 116 | | 2,990 |
| 9/19 | 277 | 94 | | 2,950 |
| 9/22 | 270 | 92 | | 2,930 |
| 9/23 | 419 | 145 | | 2,890 |
| 9/24 | 372 | 128 | | 2,910 |
| 9/25 | 382 | 117 | | 3,260 |
| 9/26 | 483 | 145 | | 3,330 |
| 9/29 | 606 | 178 | | 3,400 |
| 9/30 | 643 | 185 | | 3,480 |
| 10/3 | 389 | 136 | | 2,860 |
| Total | 4,520[a/] | 1,446 | Mean | 3,130 |

a/ Fecundity not obtained for 6 days of egg take because number of females not known.

Table 4. Gulkana incubation egg take summary, 1980, and resulting fry outmigrants, 1981.

| Incubation Unit | Substrate | Brood | Date Loaded | Estimated Eggs Seeded (Thousands) | Estimated Fry Outmigrants (Thousands) | Estimated Percent Survival |
|---|---|---|---|---|---|---|
| 1 | Intalox | Main Spring[a/] | 10/7 | 288 | 256 | 88.9 |
| 2 | Intalox | Main Spring | 10/3 | 389 | 347 | 89.2 |
| 3 | Gravel | Middle Spring | 10/2 | 309 | 284 | 91.9 |
| 4 | Gravel | Middle Spring | 10/1 | 418 | 366 | 87.6 |
| 5 | Gravel | Main Spring | 9/30 | 643 | 549 | 85.4 |
| 6 | Gravel | Main Spring | 10/8 | 228 | 192 | 84.2 |
| 7 | Gravel | Main Spring | 10/13 | 42.0 | 40.1 | 95.5 |
| 8 | | NOT LOADED | | | | |
| 9 | | NOT LOADED | | | | |
| 10 | | NOT LOADED | | | | |
| 11 | Gravel | Main Spring | 9/29 | 606 | 542 | 89.4 |
| 12 | Gravel | Main Spring | 9/26 | 483 | 244 | 50.5 |
| 13 | Gravel | One Mile Spring | 9/25-26 | 247 | 201 | 81.4 |
| 14 | Gravel | Main Spring | 9/25 | 382 | 301 | 78.8 |
| 15 | Gravel | Main Spring | 9/24 | 372 | 287 | 77.2 |

-Continued-

| Incubation Unit | Substrate | Brood | Date Loaded | Estimated Eggs Seeded (Thousands) | Estimated Fry Outmigrants (Thousands) | Estimated Percent Survival |
|---|---|---|---|---|---|---|
| 16 | Gravel | Middle Spring | 9/23 | 419 | 381 | 90.9 |
| 17 | Gravel | Main Spring | 9/22 | 354 | 323 | 91.2 |
| 18 | Gravel | Main Spring | 9/18 | 371 | 359 | 96.8 |
| 19 | Gravel | Main Spring | 9/17 | 347 | 285 | 82.1 |
| 20 | Gravel | Main Spring | 9/16 | 331 | 291 | 87.9 |
| | | Total | | 6,230 | 5,250 | 84.3 |

a/ Main Spring is the incubator pool/spring stock.

considered as the end point for each unit's incubation period and temperature unit accumulation. In the plastic saddle substrate units, a mean of approximately 232 days (759 T.U.'s) transpired until 1000 fry/day emergence occurred. Although not tested for significance, there appeared to be a lag time in emergence between gravel and plastic.

In 1980, Intalox plastic saddles substrates, used in four incubators, produced drastically lower survival rates (55.8%) than that produced by six gravel substrate incubators (79.3%) (Roberson et al. 1981). In FY 81, because of the 23.5% difference in survival in the previous year, only two units contained plastic saddles. The current year survival percentages for plastic saddles incubators were as good or better than survivals for gravel substrate incubators. The authors theorize that during the Intalox saddles' first year of use there may have been a harmful residue adhering to the saddles. The additional year of water immersion, disinfection, cement mixer cleaning and water flushing eliminated any harmful product, resulting in increased fry survival to the expected 80% range during FY 81.

The average length, weight, and developmental index of emergent fry from the plastic saddle and gravel substrate incubators were nearly identical (Table 5). The variability was statistically significant for weight ($p < .001$), length ($p < .01$), and developmental index ($p < .01$) as determinded by F-tests. Therefore, it appears that factors other than substrate type influence the size of fry at emergence.

The developmental index at emergence of the gravel and plastic substrate-produced fry shows little variance throughout the emergence period (Figure 8). This may mean that the fry emerge when they have achieved the necessary length and weight development. Fry reared in plastic saddle substrates accumulated, on the average, 41 more temperature units for incubation than fry in gravel substrate (Table 6, Figure 9). This produced a difference in emergence of approximately 6 to 7 days. Further data and analysis are necessary to adequately address this question.

Wild fry showed both a greater average in weight (177.1 mg) and a greater average length (28.0 mm) than the hatchery fry (Table 5). A possible reason for this difference is that wild fry cannot be captured during initial voluntary emergence and are captured after they have begun to feed, while the incubator-produced fry are captured immediately upon emergence before they have begun to feed.

In order to evaluate loading density this was the first year of loading incubators with more than 600,000 eggs. The two, high density incubators were compared to incubator numbers 14 and 18, which were

Table 5. Mean, standard deviation (sd), and sample size (n) for weight (mg), length (mm), and developmental index ($k_D$) for 1981 Gulkana incubation project sockeye salmon fry.

| Substrate Type | Brood Source | Estimated Eggs Loaded (thousands) | Weight | | Length | | $k_D$ | | n |
|---|---|---|---|---|---|---|---|---|---|
| | | | mean | sd | mean | sd | mean | sd | |
| Intalox | Main Spring | 288 | 144.1 | 16.6 | 27.4 | 0.87 | 1.91 | 0.034 | 151 |
| Intalox | Main Spring | 389 | 146.5 | 19.4 | 27.5 | 0.92 | 1.91 | 0.040 | 152 |
| | | | 145.3 | | 27.4 | | 1.91 | | |
| Gravel | Middle Spring | 309 | 145.0 | 15.5 | 27.4 | 0.85 | 1.91 | 0.046 | 155 |
| Gravel | Middle Spring | 418 | 148.5 | 18.8 | 27.5 | 0.95 | 1.92 | 0.055 | 151 |
| Gravel | Middle Spring | 643 | 150.6 | 19.3 | 27.5 | 0.85 | 1.93 | 0.049 | 152 |
| Gravel | Middle Spring | 228 | 139.7 | 15.8 | 27.0 | 0.82 | 1.91 | 0.039 | 149 |
| Gravel | Main Spring | 42 | 149.4 | 15.9 | 27.8 | 0.71 | 1.90 | 0.035 | 95 |
| Gravel | Main Spring | 606 | 148.1 | 15.4 | 27.1 | 0.80 | 1.94 | 0.051 | 262 |
| Gravel | Main Spring | 483 | 154.0 | 19.8 | 27.9 | 1.14 | 1.91 | 0.052 | 207 |
| Gravel | One Mile Spring | 247 | 151.6 | 18.4 | 27.6 | 0.90 | 1.92 | 0.062 | 154 |
| Gravel | Main Spring | 382 | 152.1 | 19.8 | 27.8 | 0.89 | 1.91 | 0.058 | 209 |
| Gravel | Main Spring | 372 | 152.1 | 17.5 | 27.5 | 1.26 | 1.94 | 0.063 | 155 |
| Gravel | Middle Spring | 419 | 149.6 | 17.7 | 27.5 | 0.85 | 1.93 | 0.400 | 161 |
| Gravel | Main Spring | 354 | 151.6 | 17.7 | 27.7 | 0.85 | 1.92 | 0.034 | 161 |
| Gravel | Main Spring | 371 | 146.3 | 19.7 | 27.4 | 0.90 | 1.91 | 0.050 | 163 |
| Gravel | Main Spring | 347 | 152.2 | 19.1 | 27.7 | 0.83 | 1.92 | 0.045 | 104 |
| Gravel | Main Spring | 331 | 154.0 | 19.2 | 27.8 | 0.81 | 1.93 | 0.043 | 106 |
| | | | 149.7 | | 27.6 | | 1.92 | | |
| "Natural" | "Wild" | | 177.3 | 25.7 | 28.4 | 1.31 | 1.96 | 0.33 | 300 |

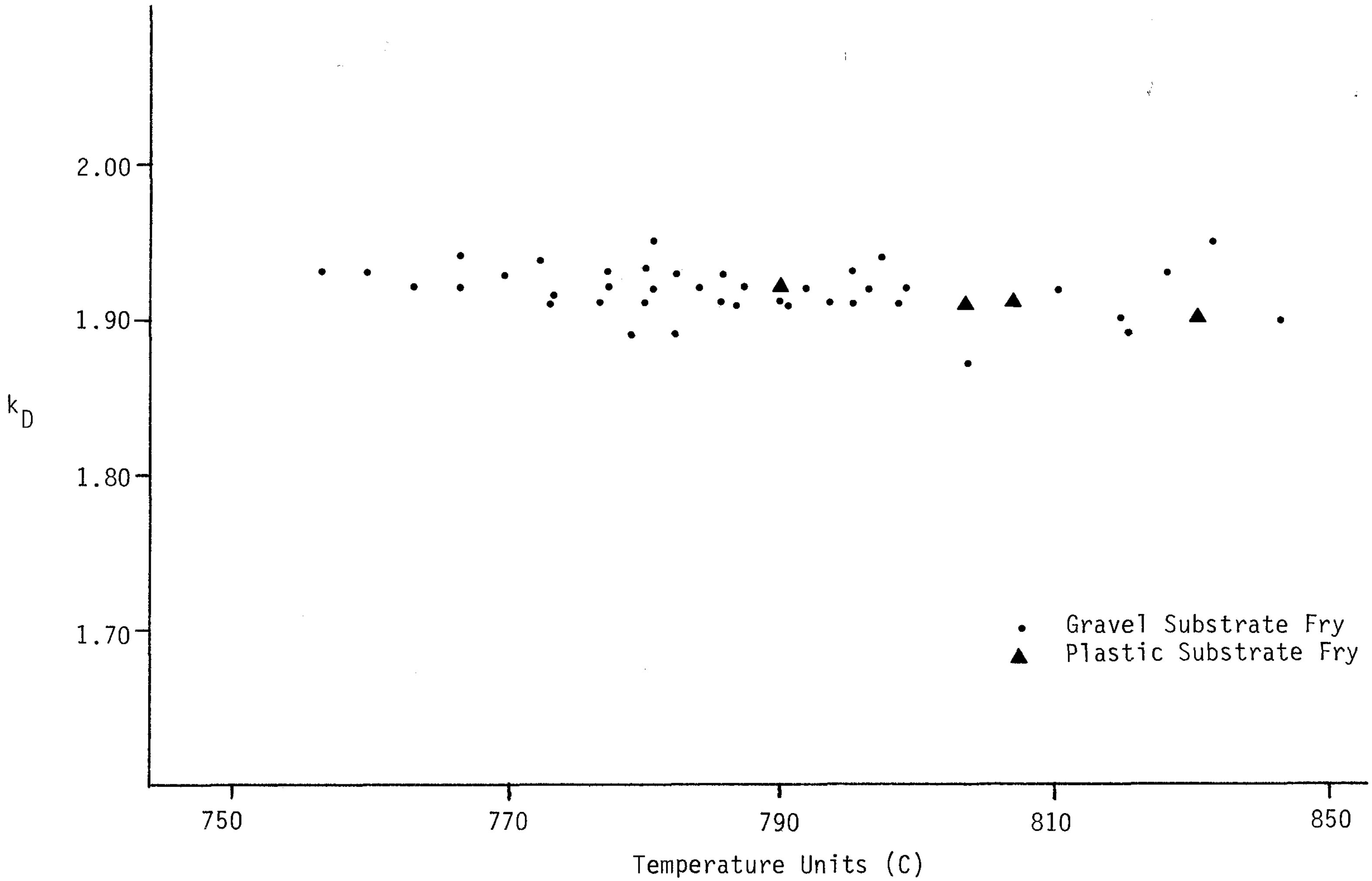



Figure 8. Comparison of gravel and plastic substrate, on the condition of development of the 1981 emergent fry.

Table 6. Number of days and temperature units ($^{o}C$) to 1000 fry/day emergence in gravel and Intalox plastic saddle substrate incubators at Gulkana incubation facility in 1980-81. Dots (...) indicate incubators were not loaded because of the lack of sufficient broodstock.

| Incubation Unit | Incubation Substrate | Days to 1000 Fry/Day Emergence | Temperature Units to 1000 Fry/Day Emergence |
|---|---|---|---|
| 1 | Intalox | 230 | 751 |
| 2 | Intalox | 234 | 767 |
| | Mean | 232 | 759 |
| 3 | Gravel | 228 | 740 |
| 4 | Gravel | 225 | 726 |
| 5 | Gravel | 217 | 691 |
| 6 | Gravel | 228 | 747 |
| 7 | Gravel | 236[a/] | 787[a/] |
| 8 | Gravel | ... | ... |
| 9 | Gravel | ... | ... |
| 10 | Gravel | ... | ... |
| 11 | Gravel | 220 | 703 |
| 12 | Gravel | 224 | 717 |
| 13 | Gravel | 227 | 729 |
| 14 | Gravel | 227 | 729 |
| 15 | Gravel | 221 | 702 |
| 16 | Gravel | 225 | 719 |
| 17 | Gravel | 224 | 713 |
| 18 | Gravel | 226 | 713 |
| 19 | Gravel | 227 | 717 |
| 20 | Gravel | 226 | 712 |
| | Mean | 225 | 718 |

a/ Flows through this unit were 23% lower than for all other units.

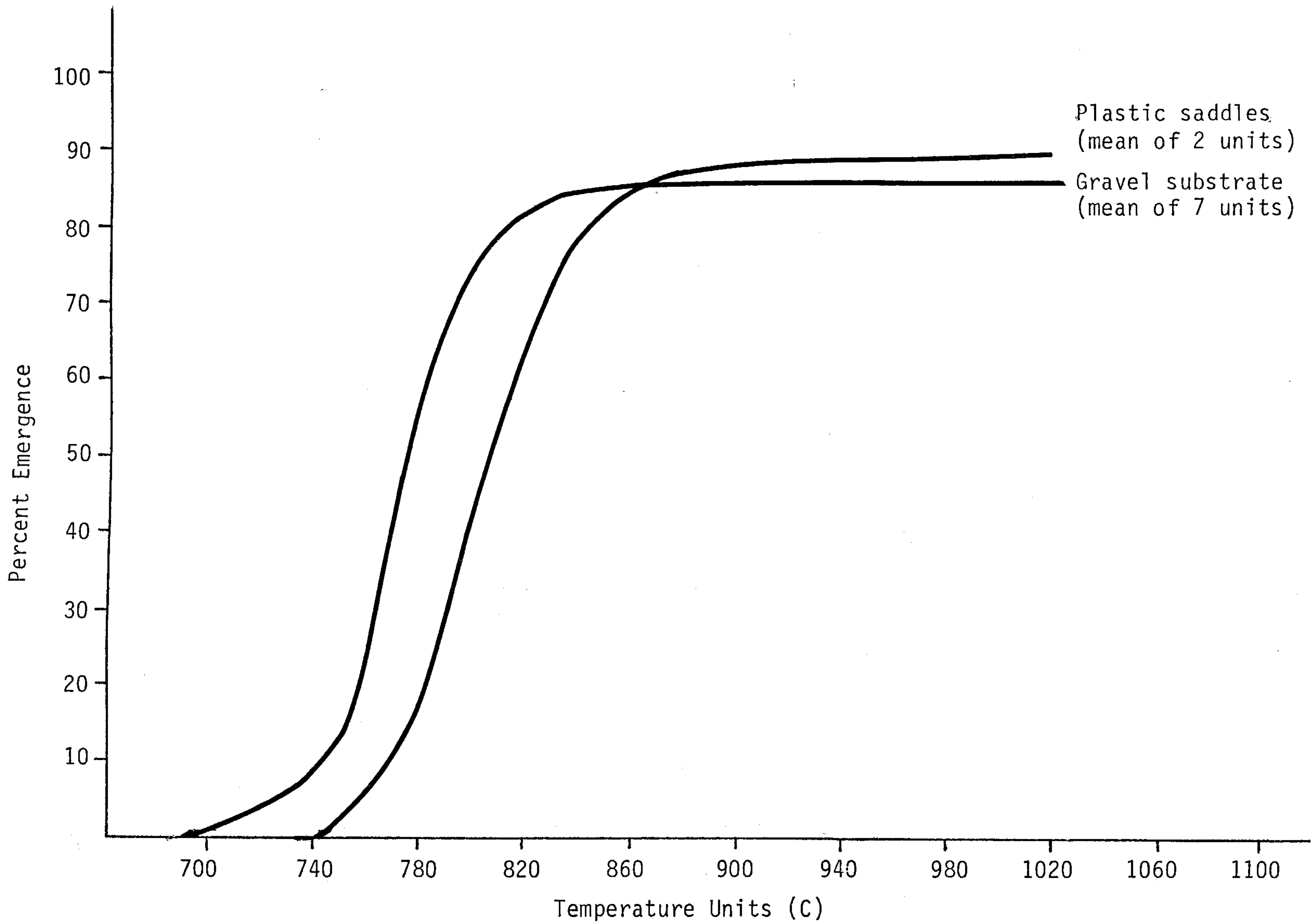



Figure 9. Comparison of gravel and plastic substrate to 1981 emergent fry timing.

loaded with 382,000 and 371,000 green eggs, respectively (Table 7). All four units being compared had gravel substrate, and their eggs all came from the same source. Even though the mean percent survival of each study group is similar (87.3% for high; 87.7% for low), there is a much wider range within study groups. This can probably be partly attributed to natural variability. The estimated mean survival percentage of the rest of the units (excluding 5 and 11 with high density, and units 1 and 2 with plastic saddles) was 82.6 percent. The survival percentage of the higher density units is good, and both are higher than the average for all the lower density units but are not higher than each individual low density unit's estimated survival rates (Table 4). Mean lengths and weights of the higher density fry were only slightly less than in the lower density units. Even though nearly 3800 alevin mortalities were present in one of the high density incubators, 85.4% survival was obtained (Table 7). The data indicate a promise for higher loading densities that warrants further research.

Smolt Coded Wire Tagging

Aerial surveys of Summit Lake confirm a very small indigenous stock of spawning sockeye salmon, that has averaged less than 10 per year from 1967 to 1980 (4 years had no surveys). Gunn Creek surveys from 1970 to 1981 indicate an average population of 184 spawners per year. Assuming half of these natural fish are females with a 3,980 egg fecundity, we would expect to have 3,860 smolts, on an average, emigrating annually from Summit Lake. This assumes a 10% survival through each life phase.

In 1981, natural stocks would have provided approximately 2.8% of the outmigrating smolts. The other 97.2% would have been transplanted Gulkana stock. The smolt emigration from 1981 transplants was estimated to be 134,000, age 1, assuming a 10% survival of the 1.34 million fry transplanted from the Gulkana incubation facility to Summit Lake in 1980. Because of late equipment delivery, the capture net was installed about 3 weeks after the ice had gone out, and it was assumed that the majority of the outmigrant smolts were missed. The total smolts captured from 16 June to 9 July was 2,378; of these, 1,442 were tagged and released, 710 were released untagged, 180 were mortalities, and 46 were recaptured and released. The recapture problem occurred because the net was located in river current that was too slow and too near the lake. It was addressed by releasing the smolts further downstream in swifter water.

This was the first year of baseline data aquisition for the smolt outmigrants from Summit Lake. Mean fork length, weight, and condition factor of sampled smolts are given in Table 8.

Observation of the smolt migration timing required that the capture trap be manned from 1700 h to 0400 h to be sure that smolts, which entered the trap, were dipped out and held in the live trap until tagging. If the smolts were not netted when initially entering the trap, they would exit the trap and escape downstream past the net. Problems were also

Table 7. Comparison of two units loaded with greater than 600,000 green eggs with two units loaded with less than 400,000 green eggs in 1980.

| Unit | Green Eggs | Survival Percentage | Alevin Mortalities | Sample Size | Mean Length (mm) and Standard Deviation | Mean Weight (mg) and Standard Deviation | Developmental Index and Standard Deviation |
|---|---|---|---|---|---|---|---|
| 5 | 643,000 | 85.4 | 3,787 | 414 | 27.3 | 149.0 | 1.94 |
| 11 | 606,000 | 89.4 | 148 | | 0.84 | 16.9 | 0.051 |
| | Mean | 87.3 | 1,968 | | | | |
| 14 | 382,000 | 78.8 | 120 | 372 | 27.6 | 149.6 | 1.91 |
| 18 | 371,000 | 96.8 | 209 | | 0.92 | 19.9 | 0.055 |
| | Mean | 87.8 | 165 | | | | |

Table 8. Mean length, weight and condition factor of outmigrating Summit Lake sockeye salmon smolts, 1981.

| Age | Sample Size | Mean Length (mm) | Length Range | Standard Deviation | Mean Weight (g) | Weight Range | Standard Deviation | Condition Factor |
|---|---|---|---|---|---|---|---|---|
| 1.0 | 110 | 92.0 | 82-106 | 5.82 | 7.64 | 4.7-11.5 | 1.36 | .967 |

encountered with the net location, currents, water level, beavers, and debris.

On several occasions, schools of 300 to 3,000 fry were observed swimming upstream past the smolt net. The origin of these fry is uncertain, but may be Fish Creek which is downstream from the trap. If this is correct, then the theory that the majority of the outmigrant smolts are from the incubation transplant could be affected. Fry were also observed going downstream past the net. These fish could have been the above mentioned fry exiting or they could have been Gulkana incubator fry or Summit/Gunn Creek fry exiting.

Adult Salmon Investigations

On 11 August, an aerial survey of the Gulkana River from Mud Creek to Summit Lake accounted for 3,075 adult sockeye salmon. Based on past surveys, this would indicate an average spawner population for the season, which means that 20 to 30 thousand sockeye would utilize the spawning grounds between Mud Creek and Summit Lake from early July to late October.

Fish Creek had an estimated run of 11,100 adult sockeye salmon. The weir was not fish-proof for one overnight period, consequently, an additional 3,000 fish were estimated to have passed during this time and were added to the actual weir count of 8,060.

To evaluate the survival of the Gulkana incubator fry to adult stage, sockeye fry have been transplanted into Ten Mile Lake (Mile 10 on Denali Highway) at 100,000 per year since 1974. From earlier aerial surveys, Ten Mile Lake or its tributary stream, Hungry Hollow Creek, did not contain an indigenous stock of anadromous fish. In 1978, the first adult returns were verified by aerial and ground surveys, with 1980 marking the third consecutive year of sockeye salmon returns to Hungry Hollow Creek. Even though survey conditions were poor, the aerial survey flight on 16 October enumerated 250 sockeye salmon in Hungry Hollow Creek. Adult sockeye salmon were also observed constructing redds and swimming around the shoreline of Ten Mile Lake. This represented at least a 0.25% survival from the approximately 102,000 fry planted in 1975. To account for straying, fishing mortality, and poor survey conditions, the actual adult survival from the fry transplant was assumed to be greater than 0.5%.

The average age-class structure of the Gulkana sockeye is approximately 11% 4-year-olds and 89% 5-year-old fish (Roberson and Fridgen 1974); thus, from the fry releases shown in Table 9, 6,475 sockeye salmon returned as 5-year-olds from the 1976 fry release and 690 returned as 4-year-olds from the 1977 fry release. The total Gulkana Incubation contribution to the adult return for 1980 was estimated to be 7,170.

Table 9. Estimated adult sockeye salmon returns from the fry releases at the Gulkana incubation site.

| | | | | | | Return Age Class | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Green Eggs | | Fry Produced | | 2.2 11% Survival | | 2.3 89% Survival | | Total Adult Returns | | Est % Survival |
| Year | Number | Year | Number | Year | Number | Year | Number | Year | Number | |
| 1973 | 256,000 | 1974 | 179,000 | 1977 | 197 | 1978 | 1,600 | 1978 | 2,570 | 1.4 |
| 1974 | 1,270,000 | 1975 | 887,000 | 1978 | 975 | 1979 | 7,890 | 1979 | 8,690 | 1.0 |
| 1975 | 1,280,000 | 1976 | 728,000 | 1979 | 800 | 1980 | 6,480 | 1980 | 7,170 | 1.0 |
| 1976 | 1,290,000 | 1977 | 627,000 | 1980 | 690 | | | | | |
| 1977 | 1,360,000 | 1978 | 581,000 | | | | | | | |
| 1978 | 1,320,000 | 1979 | 1,040,000 | | | | | | | |
| 1979 | 3,560,000 | 1980 | 2,450,000 | | | | | | | |
| 1980 | 6,230,000 | 1981 | 5,250,000 | | | | | | | |

Limnological Investigations

After this first year of prefertilization sampling, the preliminary decisions were that Summit Lake would continue to be a candidate for fertilization, with sampling continuing on a monthly basis, and that Paxson Lake would not be considered for fertilization, but sampling would continue on a quarterly basis (Koenings, personal communication, 1982).

At the present time, the complete sample analysis has not been finished by the Soldotna lab. The results of the Paxson and Summit Lake limnological investigations will be presented at a later date (Keonings, in prep.).

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